2.0 TYPES OF INSPECTIONS

2.1 OVERVIEW

The primary purpose of the dam safety inspection program is to enhance the safety of dams and appurtenant structures for the protection of downstream life and property. Dam safety inspections are made to ensure proper operation and maintenance; to identify unsafe conditions and determine why they exist; to recommend remedial measures that will make the structure safe when necessary; and to insure that the structure meets the minimum agency requirements. Remedial measures may include repairs, redesign, strengthening or reconstruction of the embankment or spillways, modification of operations, storage restrictions, and size reductions. Removal or controlled breaching of a dam so that the water cannot be impounded is also a remedial measure that is normally undertaken only as a last resort.

Four different types of dam safety inspections should be performed for all dams, regardless of their safety hazard classification:

(1) Formal technical inspections
(2) Maintenance inspections
(3) Informal inspections
(4) Special inspections

The frequency of each type of inspection should depend on the hazard classification of the dam, the condition of the dam, and current IDNR regulations.

Table 2-1
Inspection Recommendations

(1)	**Formal Technical Inspection:** Performed initially for all dams and on a regular basis (2 to 5 yrs) thereafter, depending on hazard classification and current IDNR regulations.
(2)	**Maintenance Inspections:** Performed on a regular basis (annual) for all dams; formal technical inspections may be conducted in place of maintenance inspections.
(3)	**Informal Inspections:** Performed on an impromptu, non-scheduled basis whenever the opportunity arises, or as part of a dam monitoring program.
(4)	**Special Inspections:** Performed after the occurrence of unusual or extreme events and emergencies, or as a follow-up to specific concerns.

Every inspection should consist of three to five components, depending on the type of inspection. All inspections should include the first three of following components, while formal technical inspections should also include the last two components:

(1) File review
(2) Visual inspection (field examination)
(3) Report preparation
(4) Owner education
(5) Report submittal (to IDNR)

It should be noted that the visual inspection is just one component of the dam inspection process, and that a dam safety inspection refers to the entire inspection process including the five components described above.

The dam safety inspection program for every dam should begin with an initial, formal

technical inspection. First, an evaluation of the background, design, construction, and performance history of the dam is conducted using available files and data. Second, a thorough visual inspection of the entire facility is made to assess and document current conditions. Then, the stability and soundness of the dam are assessed with conclusions and recommendations for repairs or improvements. Additional field, laboratory, and analytical studies may be required if adequate information is not available. The findings, conclusions, and recommendations should be documented in an inspection report, as discussed in Part 3, Chapter 4. All dams may require additional formal technical inspections on a regular basis for as long as the dam exists, depending on hazard classification and current IDNR regulations. The amount of background information needed, the frequency of the inspections, and the reporting procedures are dependent on the hazard classification, the size and type of dam, and current IDNR regulations. For example, high hazard dams which pose a significant risk to downstream property will require more detailed background information and more frequent and rigorous inspections than a low hazard dam with a small reservoir. The level of inspection effort should be commensurate with the potential for damage to downstream areas.

After the initial, formal technical inspection and any required remedial measures have been completed, dam safety inspections should continue to be performed to monitor and detect any unfavorable changes that might develop in the condition of the dam that would adversely affect safety. Subsequent inspections by the same personnel may not require as detailed a review of the background, design, construction, and performance history of the dam as would be required if a new inspector is utilized. However, the inspection program should continue to address the same basic issues that were addressed in the initial formal technical inspection. The continuing dam safety inspections include additional formal technical inspections for high hazard dams, and maintenance, informal, and special inspections for all dams.

A maintenance inspection is a preventive measure designed to identify problems and to develop solutions to prevent further degradation of the dam. Maintenance inspections generally involve reviewing previous inspection reports, performing a visual inspection, and completing a report form. Maintenance inspections are usually performed by the dam tender, maintenance staff, or the dam owner.

In the case of an informal inspection, the evaluation process typically consists of review of previous file data such as reports, photographs, or monitoring data, visual inspection, and completion of a report form or inspection brief. An informal inspection can be conducted at any time, and may include only

Table 2-2
Inspection Reporting Recommendations

(1) Formal Technical Inspection
- Comprehensive Inspection Report
- IDNR Inspection Report Form
- Photographic Documentation
- Submittal to IDNR for high hazard dams

(2) Maintenance Inspection
- IDNR Inspection Report Form Optional
- Inspection Brief
- Photographic Documentation
- Project Files

(3) Informal Inspection
- IDNR Inspection Report Form Optional
- Inspection Brief
- Photographic Documentation Optional
- Project Files

(4) Special Inspection
- IDNR Inspection Report Form Optional
- Inspection Brief
- Photographic Documentation
- Project Files

portions of the dam or its appurtenant structures. Informal inspections are usually conducted by project personnel or dam owners as they operate the dam to monitor known problem areas, or to provide an update on site conditions between maintenance and formal technical inspections.

Special inspections should be performed when potentially dangerous events occur (an extreme flood or seismic event, for example), when the upstream or downstream watershed conditions change (new development, for example), when newly developed, more realistic methods of analysis become available, or as a follow-up to a formal technical or maintenance inspection to deal with a specific issue.

A complete inspection report, IDNR Inspection Report Form, or inspection brief should be prepared every time an inspection is performed. A complete report should be prepared for formal technical inspections; an inspection report form or inspection brief may be used for all other types of inspections. The inspection report, form, or brief should document the observations made in the field, present any instrumentation or other performance data trends since the last report, present conclusions on the dam's apparent adequacy, and present any necessary recommendations. The IDNR Inspection Report Form was developed by IDNR staff and is included in Part 3, Appendix C. The inspection brief is an informal report that consists of a log entry in a book or on a sheet of paper denoting observed conditions, with conclusions, recommendations, or other notes as may be deemed appropriate. If, at any time, the inspector notices any adverse trends, he/she should communicate them immediately to the owner of the dam. Dam owners should refer to current IDNR regulations to determine agency reporting requirements for their dams.

The overall dam safety inspection program is a continuing process of evaluating a dam's performance based on review and analysis of performance records and field observations. A dam safety inspection performed on a regular basis is one of the most economical means a dam owner can use to assure the safety and long life of a dam and its immediate environment. The visual inspection, a component of all types of inspections, is a straightforward procedure that can be performed by any properly trained person to make a reasonably accurate assessment of a dam's condition. The visual inspection component involves careful examination of the surface and all parts of the structure, including its adjacent environment. The equipment required is not expensive, and the visual inspection component usually can be completed in less than one day. The entire inspection process will usually take longer to complete than one day, depending on the type of inspection and the complexity of the dam.

A dam, even though previously found safe by analysis and demonstrated performance, cannot be considered safe forever. Continued vigilance, visually and analytically, is essential. The integrity of the dam must be reevaluated whenever the embankment or discharge structures are damaged, and when upstream or downstream watershed conditions are significantly altered.

2.2 FORMAL TECHNICAL INSPECTIONS

A formal technical inspection of a dam is the most comprehensive inspection that will be performed. It typically consists of five components:

(1) **File review** (or compilation of an information database if it is the first formal technical inspection, or if files do not exist or are inadequate);
(2) **Visual inspection,** or field examination of the dam and its appurtenant works;
(3) **Preparation of a detailed report**;
(4) **Education and training** of the dam owner on the results of the dam inspection and other issues relating to dam safety, including potential dam failure modes. The owner should be made part of the inspection process so that he/she "buys" into the results and is committed taking recommended actions; and,
(5) **Submittal of the report to IDNR**, if so required under current IDNR regulations.

This subchapter describes the requirements for conducting a formal technical inspection. Subsequent chapters describe the actual inspection process in more detail.

The formal technical inspection should begin with a thorough review of the project files and information database, including records of site conditions, project design, dam construction and performance, maintenance records, and previous inspection reports. If the files are incomplete or non-existent, the inspector or dam owner should gather the needed information, or compile a new information database that becomes a permanent part of the owner's project files.

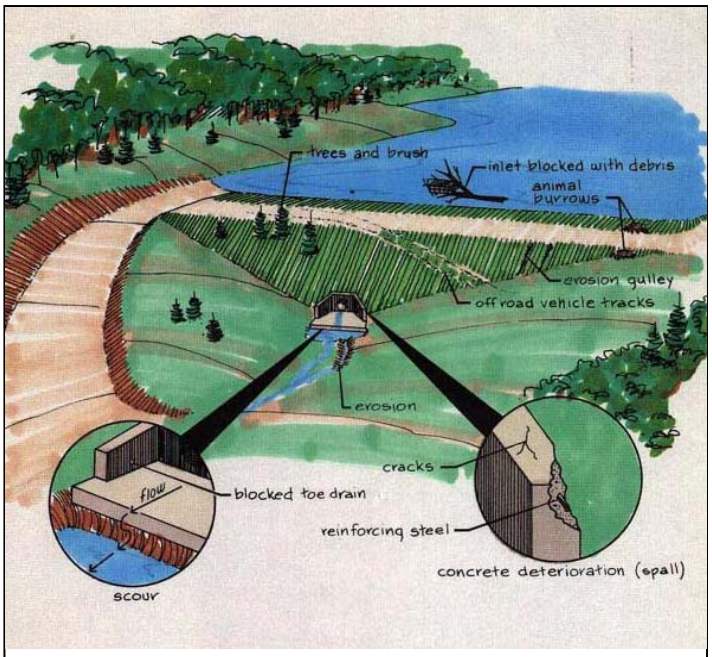

Figure 2-1 Sketch of typical dam features requiring visual inspection.

A formal technical inspection should begin with a review of the hydrologic/hydraulic calculations and geotechnical data to determine if the structures meet current accepted design criteria and practices. If these calculations have not been performed, the inspector should make an estimate of the adequacy of the spillway and embankment stability based on the best available information, followed by recommendations for a hydrologic and hydraulic analysis of the watershed and the dam, and a geotechnical evaluation of the embankment and foundation. It is important that the calculations include overtopping and spillway capacity estimates, slope stability analyses, and embankment seepage analyses. Obviously, if the same inspector performs the dam inspections all the time, he/she will not have to review the hydrologic/hydraulic

calculations and geotechnical data every time an inspection is performed.

A visual inspection, or field examination of the dam, its appurtenant works, and the surrounding areas is conducted after the file review and information database is completed. The visual inspections are made to evaluate the safety and integrity of the dam and appurtenant structures in all aspects. Underwater examinations should be performed as needed. Access routes to the dam site and to the individual operating stations should be examined for general suitability, for reliability during periods of adverse weather, and for access during periods of high water or emergencies. A review of the Emergency Action Plan or Emergency Response Procedures should be performed if one has been prepared.

After reviewing all applicable file data and completing the field inspection, conclusions should be made regarding needed monitoring, or remedial measures for repairing, strengthening, altering, or restricting operations. Necessary monitoring and/or remedial measures and their timing should then be recommended. Recommendations should also be made for conducting additional site investigations and engineering analyses, if they are necessary. Chapters 3 through 8 of Part 3 provide additional details on how to prepare for and conduct the visual inspection.

In some cases, sufficient information might not be available in the files or from what can be observed on the ground to provide a solid information base, or a basis for knowing that the dam, its appurtenant works, or the foundations are adequate as they currently exist. In other cases, dam plans and design information may not be available or may not have been prepared before the dam was constructed. In such instances, the inspector should recommend specific investigations that might be necessary to obtain the data, including surveys, geologic mapping, drilling and sampling, laboratory testing, installation of instrumentation, hydrologic studies, geotechnical, and other engineering analyses, especially if the dam's integrity is in question. The recommendations for investigations should be included in the inspection report that is completed following the visual inspection.

A detailed inspection report should be prepared after the visual inspection is performed to document the background information, design, construction and operational issues, as well as the field examination, with conclusions and recommendations. The report should also include pertinent photographs, a completed IDNR Inspection Report Form, and applicable supporting data. The report should be placed in the owner's project files and submitted to IDNR if required under current IDNR regulations. Chapter 4 of Part 3 describes recommended procedures for documenting and reporting dam safety inspections; Appendix E of Part 3 contains a recommended sample outline of an inspection report.

Formal technical inspections should be the initial inspection for all dams, regardless of hazard classification. After that, formal technical inspections should be performed on high hazard dams every two years, unless otherwise required by current IDNR regulations. Formal technical inspections are not normally performed on low and

significant hazard dams unless changing conditions warrant them.

Formal technical inspections typically should be made by a team of one or more professional engineers, geologists, or qualified technicians, accompanied by the dam owner or his representative. Composition of the group is determined by the type of dam and its appurtenant works, and the condition of the dam. The required qualifications of personnel carrying out formal technical inspections are described in Chapter 3. The inspectors must be familiar with the design and construction of dams and qualified to make assessments of structure safety.

Figure 2-2 These inspectors are checking freeboard with a level and stadia rod.

In summary, a formal technical inspection should include the following sequence of work elements:

1. Existing data are collected, reviewed, and compiled in an information database (as discussed in Chapter 3). If a dam has instrumentation, the data and analyses of the data should also be collected and reviewed. If an information database is already compiled in a project file, the first step consists of a file review.

2. Using the existing data, the inspector assesses the embankment, spillway, and outlet adequacy and performance. The embankment must be stable under all operating conditions and the spillway and outlet must be capable of safely passing the design flood. The absence or insufficiency of information essential to this part of the inspection (such as foundation characteristics, materials engineering properties, hydrological data, hydraulic analysis, and site seismicity) is identified and actions required to obtain the information are recommended.

3. A visual inspection (or field examination) is then performed to determine the present operational status of the dam, to identify existing or developing dangerous conditions, and to identify the risk to the downstream areas. (Field examination techniques are described in Chapters 4 through 8.) An inspection checklist is an excellent tool to guide the inspector during the field examination. Photographic documentation should cover all components of the dam, including components that are in good condition as well as components that are deteriorating or damaged.

4. The need for additional information should be identified and recommended in the inspection report. If required, supplemental data should be acquired by

exploratory drilling, laboratory testing, reference to published hydrological data, estimation, and special studies.

5. Using the available information, analyses, supporting calculations, and field findings, the inspector prepares a list of conclusions and recommendations.

6. The observations made during the field inspection, the analytical findings, conclusions, and recommendations are documented in a comprehensive inspection report that may include appendices for special studies, laboratory and field-testing, revised flood estimates, photographs and other supporting data. The IDNR Inspection Report Form contained in Appendix C should be completed and included in the report. If the dam safety ratings on the IDNR Inspection Report Form change from the previous ratings, the inspector must provide documentation to support the revised ratings.

7. After or during the preparation of the inspection report, the inspector should discuss the results of the inspection with the dam owner or his/her representative to educate him/her on the findings. It is important that the owner is fully aware of the findings and recommendations, particularly if deficiencies exist, and repairs or further evaluations are required. The inspector should encourage the owner to perform all recommended repairs, evaluations, monitoring, maintenance, etc. within a time period that is appropriate for the required action.

8. The formal technical inspection report may need to be submitted to IDNR for high hazard dams, and for other dams if required by current regulations. This step also includes any report revisions that may be required by IDNR. A copy of the report should be placed in the dam owner's project file.

9. Finally, the inspector should summarize and document the dam's deficiencies on the National Performance of Dams Program (NPDP) website at Stanford University. The IDNR should be contacted for additional information concerning the NPDP.

Chapter 3, Part 3 contains recommendations for a complete information database that should be assembled during the formal technical inspection if not already available.

2.3 MAINTENANCE INSPECTIONS

Maintenance inspections are performed to gather information on the current condition of the dam and its appurtenant works. This information is then used to establish needed repairs and repair schedules, and to assess the safety and operational adequacy of the dam. Maintenance inspections are also performed to evaluate previous repairs.

The purpose of maintenance inspections is to keep the dam and its appurtenant structures in good operating condition and to maintain a safe structure. As such, these

inspections will minimize long-term ownership and liability costs, and will extend the life the dam. Maintenance inspections should be performed more frequently than formal technical inspections in order to detect at an early stage any developments that may be detrimental to the dam. These inspections involve assessing operational capability as well as structural stability. The purpose of maintenance inspections is to detect any problems and correct them before the conditions worsen. The field examinations should be made by the personnel assigned responsibility for monitoring the safety of the dam. If the dam or appurtenant works have instrumentation, the individual responsible for monitoring should analyze measurements as they are received and include an evaluation of that data. The IDNR Inspection Report Form or an inspection brief should be prepared following the field visit (an IDNR Inspection Report Form is recommended).

Maintenance inspections should include the following four components at a minimum:

(1) **File review** (of past inspection reports, monitoring data, photographs, maintenance records, or other pertinent data as may be required);
(2) **Visual inspection** (field examination of the dam and its appurtenant works);
(3) **Preparation of a report** (IDNR Inspection Report Form or inspection brief, withapplicable documentation and photographs. The report should be filed in the dam owner's project files); and,
(4) **Education and training** (if someone other than the owner is performing the inspection).

Maintenance inspections begin with a review of past inspection reports and a cursory review of the complete project file if necessary, paying particular attention to potential trouble spots. The inspector should then perform a visual inspection, or field examination of all physical features and any adjacent endangering conditions. The field examination is a comprehensive search for evidence of deterioration of materials, developing weaknesses, and unsafe hydraulic and structural behavior. An inspection checklist is a valuable tool that can be used during maintenance inspections. The field examination should include photographic documentation of all the components of the dam, including components that are in good condition as well as components that are deteriorating or damaged.


Figure 2-3 Maintenance inspection of spillway outlet.

Maintenance inspections should be performed at regular intervals, normally at least once every year, although in special cases more frequent inspections might be called for. Formal technical inspections may be performed in place of maintenance inspections, and the field examination procedures are generally the same for both. For example, if the subject dam has a high hazard classification and requires formal technical inspections periodically, an additional maintenance inspection is probably not required during the years that the formal

technical inspection is conducted. In this example, the maintenance inspections would be performed in the years that the formal technical inspections are not conducted. For low and significant hazard dams, formal technical inspections are not routinely conducted after the initial formal technical inspection, therefore the maintenance inspections are the primary component in the dam operation plan. Adjustments can be made in the inspection frequency where unusual or special circumstances warrant. Successive inspections may be made in different months of the year in order to benefit from extremes in reservoir stages and differences in seasonal climatic effects.

The dam owner or maintenance personnel familiar with the project typically conducts the maintenance inspections. The dam safety professionals involved in the formal technical inspections may accompany the inspector, if requested. The inspectors are guided by their familiarity with the complete history of the dam. Their observations, evaluations, and recommendations should be documented on the IDNR Inspection Report Form or an inspection brief and placed in the owner's project file. Field examination techniques appropriate for maintenance inspections are discussed in Chapters 4 through 8, and a sample checklist for field examinations is contained in Appendix B. The field examination procedures for maintenance inspections are generally the same as those employed during formal technical inspections.

2.4 INFORMAL INSPECTIONS

The third type of inspection, an informal inspection, is a continuing effort by on-site personnel (dam owners, dam operators, and maintenance personnel) performed during the course of their normal duties. Informal inspections will provide a continuous surveillance of the dam and are critical to the proper operation and maintenance of the dam. They consist of frequent observations of the general appearance and functioning of the dam and appurtenant structures. Normally, personnel who are not professional engineers or geologists will make informal inspections; they could be dam owners, operators, maintenance crews, or other individuals whose duties place them near the dam at regular intervals. These personnel are the "first line of defense" in assuring safe dam conditions, and it is their responsibility to be genuinely familiar with all aspects of the dam. Their vigilance in observing the structure, walking the dam, checking the operating equipment, and noting changes in conditions may prevent serious mishaps or dam failures.

Figure 2-4 Photographic documentation of embankment slide.

Informal inspections are very important and should be performed at every available opportunity. These inspections may only cover one or two dam components as the

occasion presents itself, or they may cover the entire dam and its appurtenant structures. The informal inspections are generally not as inclusive as formal technical and maintenance inspections, but should always include at least the following three components:

(1) **File (or data) review** (of past inspection reports, monitoring data, photographs, maintenance records, or other pertinent data as required);
(2) **Visual inspection** (field examination of the dam, its appurtenant works, or selected features and components); and,
(3) **Preparation of a report** (IDNR Inspection Report Form or inspection brief, with applicable documentation. The report should be filed in the dam owner's project files).

An IDNR Inspection Report Form may or may not be completed; an inspection brief (short note in a logbook or on a sheet of paper) may be recorded and placed in the project file instead. Photographic documentation may or may not be included in the inspection, depending on the type(s) of problems found. Informal inspections are usually conducted to monitor known problem areas, or to provide an update on site conditions between maintenance and formal technical inspections.

2.5 SPECIAL INSPECTIONS

Special inspections may need to be performed to resolve specific concerns or conditions at the site on an unscheduled basis. Special inspections are not regularly scheduled activities, but are usually made before or immediately after the dam or appurtenant works have been subjected to unusual events or conditions, such as an unusually high pool level, rainstorm, or a significant earthquake. A special inspection may also be performed during an emergency, such as an imminent dam breach, to evaluate specific areas or concerns. They are also made when the ongoing surveillance program identifies a condition or a trend that appears to warrant special evaluation. Special inspections should focus on those dam components that are affected by the unusual event, and should include at least three components: (1) review of applicable files or data, (2) visual inspection, and (3) report preparation. An IDNR Inspection Report Form may or may not be completed, depending on the specific situation. The findings may be recorded in a log book or on a sheet of paper (inspection brief) that is then placed in the project files.

More detailed site investigations may be required (such as drilling, surveys, or seepage flow estimates) if the special inspection reveals deteriorating dam conditions. Photographic documentation is usually included as part of the inspection if damage to dam components has occurred.

Dam owners should be aware of site specific conditions that could affect the performance of their dam. Part 1 discusses geologic conditions that could impact dam operation. Figure 2-5 shows maximum recorded 24-hour precipitation events in the

United States through 1988 (these values are not PMP values used in design). It shows actual rainfall events that have occurred, and provides an indication of the potential for extreme events. Figure 2-6 shows seismic contours in the Indiana area that represent horizontal acceleration from a seismic event with a 90% probability of not being exceeded in 250 years (typical design values). In general, areas that have acceleration values greater than 10 (i.e., horizontal acceleration values greater than 0.10 times the acceleration due to gravity) should always include a seismic stability analysis of the embankment.

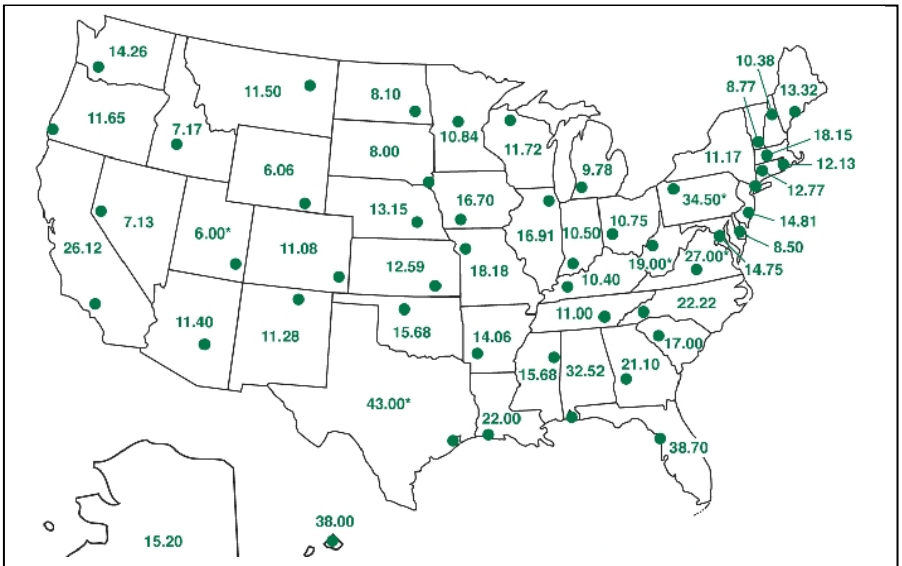

Figure 2-5 Record maximum 24-hour precipitation (in.) through 1998. Source: National Climatic Data Center/ National Oceanic and Atmospheric Administration (NOAA)

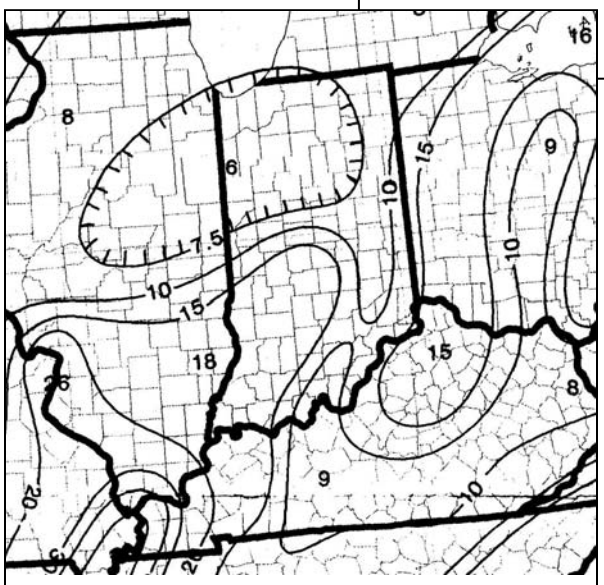

Figure 2-6 USGS seismic contour map, expressed as a percentage of gravity.

Source: Department of the Interior, U.S. Geological Survey